SECTION 4. FORMULATING ALTERNATIVE PLANS

4.1 OVERVIEW OF PLAN FORMULATION PROCESS

This section outlines the process taken by the study team to formulate restoration measures and develop alternatives by combining the measures as appropriate.

4.2 IDENTIFYING RESTORATION MEASURES

The aim of the restoration activities is to restore the aquatic and riparian resources of the river corridor. Channel modification, dam construction, urbanization, ongoing development of the upper watershed, and industrial development have been identified as the primary causes of adverse ecological impacts to the stream. Habitat degradation in the stream corridor increases in the downstream direction along the Mill River from the upper reaches in Stamford to Long Island Sound.

An ecosystem approach to restoration was specifically applied to the Mill River by working toward the following intentions:

- Re-establishing fish passage to the upper reaches of the Mill River
- Increasing the river's baseflow by providing more opportunities for stormwater infiltration
- Improving the water quality of urban stormwater runoff through treatment;
- Restoring valuable wetland habitat
- Prioritizing restoration locations by habitat function and value;
- Evaluating riparian habitat health and function to best preserve, protect, and enhance biodiversity and self-regeneration
- Recommending best management practices for the Rippowam Watershed

Within the project area, the study team conducted a field investigation to identify restoration opportunities including erosion problems, degraded water bodies, in-stream habitat degradation, urban stormwater flows, potential for wetland restoration, and need for fish passage enhancement. The study team, including the city of Stamford, identified 20 locations for possible restoration activity within the project area (Figures 7 and 7a). All of the proposed restoration locations are described in Appendix I. Field evaluations focused on fish passage enhancement and habitat preservation in areas adjacent to the Mill River and Mill Pond. Using information gathered during site visits and a review of existing data, brief descriptions of each proposed restoration location site as well as general biotic and site feasibility information were documented. All site assessments were completed based on existing site conditions.

Using the environmental and economic information gathered for the watershed, screening criteria were developed to select sites for proposed restoration. Criteria for site selection included site conditions, environmental benefits, long-term viability, engineering

feasibility, and cost effectiveness. See Section 4.2 for a full description of potential restoration location selection and evaluation.

Of the twenty possible restoration actions evaluated, ten were recommended for further analysis: Sites 1, 2, 6, 9, 10, 11, 12, 13, 17, and 18 (See figures 7 and 8 for locations. See also Appendix I for the complete list of potential restoration activities). Table 2 (below) describes the ten selected sites. These recommendations were based on the restoration rating, which considered such variables as habitat significance, presence/absence of exotics, instream habitat, potential for habitat improvement, and educational opportunities. These scores were used as a guideline to prioritize restoration sites for recommendation, as higher scores represented a greater benefit. On-site verification, evaluation, and professional judgment were also used in the selection process. Sites 11, and 12, and 13 were selected for their high potential for habitat restoration, including anadromous fish passage. Sites 2 and 6 were selected because they are considered to be important estuarine areas. Site 1 was selected because it has the potential to provide enhanced fish passage (a primary goal of the overall project). Sites 9, 10, and 18 were selected because they provide opportunities for riparian restoration in conjunction with wetland and floodplain areas, providing connection betweens these ecosystems. Site 17 was selected as an area to restore wetlands and floodplain in the lower river corridor.

Sites 3, 4, 5, 7, and 8 were not selected due to low restoration potential as reflected in the low restoration rating. Those with a high restoration rating that were not chosen included Site number 14 due to existing infrastructure constraints, Site 15 did not provide high potential for instream habitat, Site 19 and 20 showed good restoration potential but were not considered habitats under threat nor critical to the overall aquatic health of the Mill River.

Table 2. Potential Projects Identified During Field Investigations (See Figures 7 and 8 for Location Maps of sites)		
Site Location	**Current Conditions**	**Proposed Restoration Action**
1	Abandoned concrete blocks and gate structures directly underneath Pulaski Street Bridge. Structures block fish passage at lower tides.	Remove portions of the fish blockage to restore fish passage at low tide.
2	Tidal flat dominated by *Phragmites* sp. Area lies directly in front of city-owned property.	Tidal wetland restoration. Restore area to a tidal wetland by regrading and planting of desired vegetation. Invasive species removal.
6	Tidal flat dominated by *Phragmites* sp. Area lies directly in front of city-owned property.	Tidal wetland restoration. Restore area to a tidal wetland by regrading and planting of desired vegetation. Invasive species removal.
9	Empty lot located on the east bank of the river downstream of the Main Street Bridge. Area is dominated by invasive exotics. Provides little shading or habitat value.	Riparian restoration by planting of desirable riparian species. Regrade lower portion to include a wetland area. Manage or remove any exotic species. Trail system to connect greenway along river corridor.
10	Floodplain located on the east bank of the river just downstream of the Main Street Bridge. Area is dominated by invasive exotics. Provides little shading or habitat value.	Riparian restoration by planting of desirable riparian species. Regrade lower portion to include a wetland area. Manage or remove any exotic species. Connect trail system in Mill River Park to City-provided trail that connects to Main Street Bridge pedestrian crossing.
11	Retaining wall located on west bank of river directly adjacent to Mill Pond Road. Has numerous stormwater discharge pipes. Constriction made by road and wall does not allow a walkway for foot and bike traffic.	Structural reinforcement and stabilization. Vegetation planting at base of wall. Incorporate a sidewalk for pedestrian and bike traffic to connect park system.
12	Main Street dam forming Mill Pond. Dam is failing and needs structural reinforcement. Collects trash and causes sedimentation behind dam within the Mill Pond.	Remove Main Street dam and restore a geomorphologically correct river channel, which includes a number of pool and riffle sequences.
13	Mill Pond located in downtown Stamford. Currently a trap for sediment and trash. Vertical concrete walls provide little habitat value. Large population of Canada geese and mute swans.	Restore a geomorphologically correct river channel. Remove concrete walls and create floodplain that incorporates a trail/boardwalk system as well as overlooks and educational facilities. Maintain as many Cherry Trees as possible within Mill Pond Park.
17	Parking lot located on the Wright Technical School property. School is located on the west bank of the river and just south of Scalzi Park. Parking lot is adjacent to the river and near a pedestrian bridge joining the park with the east side of the river.	Create a stormwater wetland and natural teaching area to treat run off from the school grounds. Riparian restoration through planting of desirable riparian species. Manage or removal of exotic species. Trail system to connect greenway along river corridor.
18	Riparian corridor on west bank of Mill River located between Wright Technical School and Mill River. Vegetation is composed of primarily of Japanese knotweed, an invasive exotic. Provides little shading or habitat value.	Riparian restoration through planting of desirable riparian species. Manage or remove any exotic species.

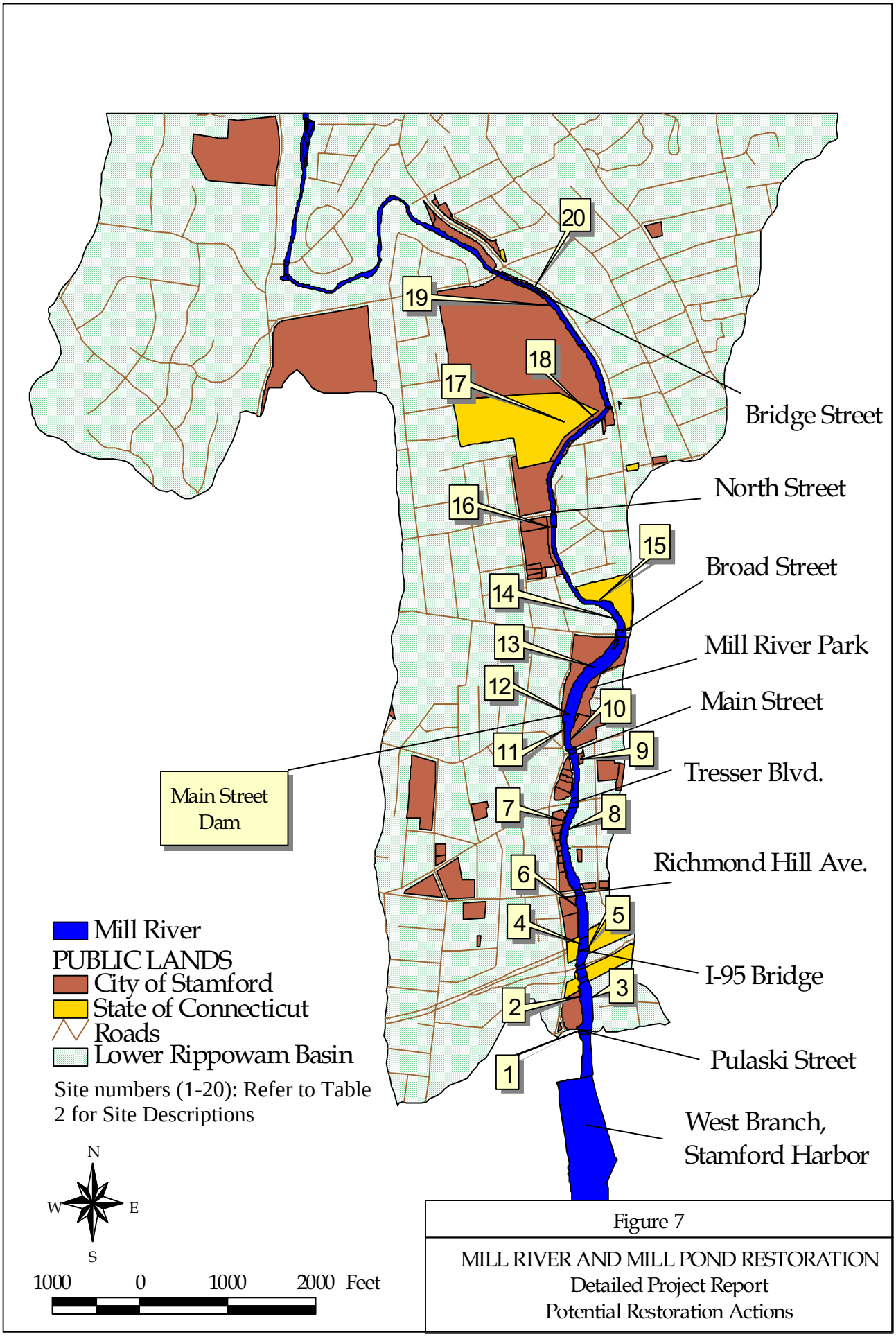

Figure 7. Locations of Potential Restoration Actions

Mill River Restoration Sites

Legend

- Road Centerlines
- Restoration Sites

Figure 8. Aerial Photo of Locations of potential Restoration Actions.

(Refer to Table 2 for description of 20 Sites.)

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New England District

4.2.1 City of Stamford's Greenway Planning

The city of Stamford, the non-federal sponsor, is dedicated to expanding and enhancing the Mill River riparian corridor as a wildlife passageway and urban green space. The city currently has a number of projects underway to restore the riparian corridor and floodplain of the Mill River. In 1997, the city commissioned Sasaki Associates to study the creation of a Mill River corridor (Sasaki *et al.* 1999). The proposed greenway will provide city residents with open space for recreation and public gatherings, as well as opportunities to interact visually and physically with the Mill River (Sasaki *et al.* 1998; 1999).

Greenways provide multiple environmental and cultural benefits (Ahern 1995). Restoring a contiguous open stream and its associated floodplain and riparian buffer improves local hydrology and sediment transport as well as habitat. A park system designed around a stream channel serves as a wildlife corridor and lends itself to the siting of recreational trails.

Integral to the city's plan for a greenway is restoration of the Mill River. The river would become the focal point of the park system, from which connections to downtown Stamford, commuter rail, other urban parks, and surrounding neighborhoods would be strengthened. River restoration will introduce the residents of Stamford to local biodiversity and give them the opportunity to explore a variety of habitats from estuarine wetlands to riparian floodplain.

Habitat restoration that also facilitates learning ultimately ensures the future protection and care of the natural resource. A rise in the number of watershed associations and adopt-a-stream groups demonstrates the interest of residents to the Mill River (Pinkham 2000). Educational opportunities and aesthetic resources on the Mill River have been evaluated and rated to prioritize restoration sites. A Mill River reach north of Broad Street that includes a technical college, a middle school, and an elementary school provides an excellent opportunity to teach about natural systems. This area has been targeted for efforts, including the restoration of wetlands and native riparian vegetation, as well as the retention and treatment of stormwater.

4.2.2 Watershed Best Management Practices

Urban runoff carries elevated levels of nutrients, metals, pesticides, and organic contaminants (Paul and Meyer 2001). These impacts, as well as increased sediment loads or other common urban development impacts may affect stream restoration sites (Ferguson 1991b). Consequently, urban stream restoration requires planning and analysis of sites upstream, downstream, and laterally adjacent to the restoration site.

An important component of the Mill River restoration project is the consideration of Best Management Practices (BMPs) to mitigate urban development impacts. Stormwater BMPs are commonly recommended practices to sustainably manage water resources. They may include features or methods to detain, infiltrate, and treat stormwater

(Ferguson 1991a). Combining stream restoration with on-site stormwater treatment by employing selected BMPs is generally the most successful strategy to ensure downstream water quality and habitat enhancement (Lawrence *et al.* 1996). While restoration activities may include and demonstrate key BMPs, the community is responsible for the development of watershed and urban practices to manage their water resources.

A variety of stormwater BMPs can be designed to provide some of the following benefits:

- Augment base flows through dry periods by improving groundwater recharge
- Uptake excess nutrients
- Intercept floatables (such as organic debris and trash) and sediment while slowing overland flow
- Attenuate pollutants through soil microbial activity, fixation in plant tissues, or filtration through soil materials
- Prevent erosion by intercepting runoff and moderating slopes
- Prevent increased overbank flooding while providing safe conveyance of extreme floods

Potential BMP's that can be constructed under the Section 206 program to complement and safeguard stream restoration have been identified along the length of the Mill River project area, including:

- Restoration of a filled wetland and floodplain on an overflow parking lot near the JM Wright Technical School
- Restoration of floodplain and riparian buffers and filter strips designed to improve stormwater quality and intercept and capture overland flows
- Restoration of fringe wetlands in upstream and tidal reaches to capture urban runoff

Other BMP's that would help improve water quality and protect the aquatic resources, but may not be authorized under the Section 206 program include:

- Forebay areas and infiltration basins for stormwater outfalls at many locations
- Porous paving materials utilizing cellular confinement systems
- Bioretention facilities associated with urban land use in site-specific locations inside the 100-foot river buffer

4.2.3 Identified Restoration Measures

As a result of the inventory and consideration of restoration potential and Stamford's Greenway planning, the following restoration measures were formulated for the lower 2.5-mile reach of the river:

- Mill Pond and Main Street Dam Site Restoration: Restoration of a quarter mile of riverine and riparian habitat at the Mill Pond and Main Street Dam site and

opening up anadromous fish passage to 4.5 miles of river habitat (Sites 10, 11, 12, and 13) upstream of the dam and a total of 5.2 river miles (31.5 acres) from Pulaski Street Bridge

- Riparian habitat restoration along additional reaches of Mill River, totaling an additional 1.53 acres, where invasive vegetation would be removed and replaced by native riparian woody and herbaceous vegetation (Sites 9, 10, 11, and 18)
- Restoration of freshwater wetlands along the river reach by creating a one-acre wetland area adjacent to the river on a low-lying floodplain that now contains a parking lot at the J.M. Wright Technical School grounds (Site 17)
- Restoration of 0.8 acre of tidal wetlands, where invasive species, including *Phragmites*, dominate the site, by removing the invasive species, re-grading the sites to enhance tidal flushing, and planting native salt marsh vegetation (Sites 2 and 6)
- Restoration of unrestricted river flow at Pulaski Street Bridge by removing abandoned concrete blocks and gate structures beneath the bridge, that partially block movement of anadromous fish and other aquatic species in the tidal portion of the river (Site 1)

Restoration of the Mill Pond and Main Street Dam site involved examining four options, including the no-action alternative, treated as separate alternatives:

- No action, in which the dam and channelized, sediment-filled impoundment would remain in place, and no riparian habitat would be restored
- Removal of the dam and concrete retaining walls along the river and restoring the river reach to a naturally shaped channel with a riffle pool sequence, sinuous shape, and 4 acres of riparian-vegetated floodplains along the channel
- Removal of the dam and concrete retaining walls and creating a series of stepped pools along the reach with one-foot high weirs that form still-water pools, and restoration of 4 acres of riparian-vegetated floodplains along the channel
- Construction of a fish ladder on the Main Street Dam, while leaving the dam in place, partial removal of the concrete retaining walls along the impoundment, and dredging out and widening the impoundment, and restoration of 2.9 acres of riparian habitat along the pool

Removal of the dam without removing the walls was formulated, but was dropped from further consideration. This measure would create a channelized reach with walls that would need additional protection at considerable expense with no restoration benefit to the currently impounded reach. Partial wall removal is considered in Alternative 4 because the dam remains in place, and complete wall removal would compromise the structural stability of the dam.

4.3 FORMULATION OF ALTERNATIVES

The restoration measures were combined in various ways to produce four alternatives, including the no-action alternative, that were analyzed in detail. These alternatives represent a range of options from a much larger set of originally conceived actions. Design considerations for alternatives included site conditions, environmental benefits, long-term viability, engineering feasibility, and cost effectiveness (discussed in greater detail in Section 6). Each construction alternative (other than the no-action alternative) provides a specific restoration measure for the Mill River Park reach of the river. In addition, all construction alternatives include four restoration measures, which were added to the alternatives to increase habitat restoration goals.

The following represent alternatives analyzed in detail in this report for restoring the Mill River and Mill Pond in Stamford, Connecticut.

4.3.1 Alternative 1: No Action

No alterations to the Mill River or Mill Pond would be performed. Additionally, no actions would be performed to restore riparian areas, wetlands, saltwater marsh, and free flow along the river.

The Mill Pond landscape would remain unchanged. Historic cherry trees and other vegetation would remain in their current locations. The concrete walls bordering the pond and dam would remain in place, and both the walls and dam would require continued maintenance. Sediment from a variety of watershed sources (e.g., stormwater runoff) would continue to be deposited in Mill Pond, thus requiring regular dredging and maintenance by the city of Stamford. For example, the city removed 3,500 cubic yards of sediment from the pond in 1996, and the city pursued permitting in 2002 to remove up to 9,000 cubic yards in the future. However, specifically the harbor up to the Water quality within Mill Pond would continue to be impaired. The Main Street Dam would continue to block the migration of anadromous fish species to at least 4.5 miles of the Rippowam River system. The dam would also block movement of freshwater and saltwater species, since the dam is at the upper end of the tidal zone of the river. Leaving the dam in place would require immediate gate repair and continued structural reinforcement.

The no-action alternative would have no construction cost, but would have a high maintenance cost to maintain the existing channelized impoundment behind the dam.

4.3.2 Alternative 2: Dam Removal and River Channel Restoration

Alternative 2 combines the following measures:

- Removal of the Main Street Dam and concrete retaining walls and restoration of a natural stream channel through a quarter-mile reach of Mill River, thereby opening up 4.5 miles of riverine habitat to anadromous fish upstream of the dam

and a total of 5.2 river miles (31.5 acres) from Pulaski Street Bridge. This option also would restore 4 acres of riparian habitat through the Mill River Park (Sites 11, 12, and 13). (See Figure 9).

- Additional riparian habitat restoration along the river, totaling an addition of 1.53 acres, at Sites 9, 10, 11, and 18 by planting native woody and herbaceous vegetation and removing exotic and invasive plant species.
- Creating a one-acre wetland area adjacent to the river at the J.M. Wright Technical School grounds (Site 17) (See Figure 10).
- Restoration of 0.8 acres of tidal wetlands by re-grading banks and planting native salt marsh vegetation (Sites 2 and 6).
- Removal of abandoned concrete blocks and gate structures beneath the Pulaski Street Bridge to open up the river and provide unobstructed passage of anadromous fish and other aquatic species (Site 1).

To facilitate fish passage and allow continual flushing of sediment, the Main Street Dam would be removed. Concrete retaining walls would also be removed and banks sculpted to restore a riparian corridor through the city park. A stable river that effectively transports the imposed discharge and sediment load would be re-established through the former Mill Pond. The configuration of the natural channel design, along with the selective placement of boulders and other rock structures in the stream channel, would restore an in-stream pool-and-riffle sequence within the park reach. The deeper pools would be self-maintained by natural flushing during high river flows.

Sediment (approximately 18,600 cubic yards) that has collected behind the dam would be excavated. Initial sediment tests show that the sediment is not hazardous, but contains contaminants at levels that do not allow for residential disposal (see Appendix H, Sediment Chemistry Analysis). Sediment would be further tested as needed to determine the extent of contamination and the appropriate disposal methods. All materials determined inappropriate for disposal in residential and/or industrial/commercial areas would be transported to an appropriate disposal site. The Manchester Municipal Landfill in Manchester, Connecticut has already been approved by the state of Connecticut for the disposal of this material, based on state permitting determinations to date (see Appendix D, Pertinent Correspondence).

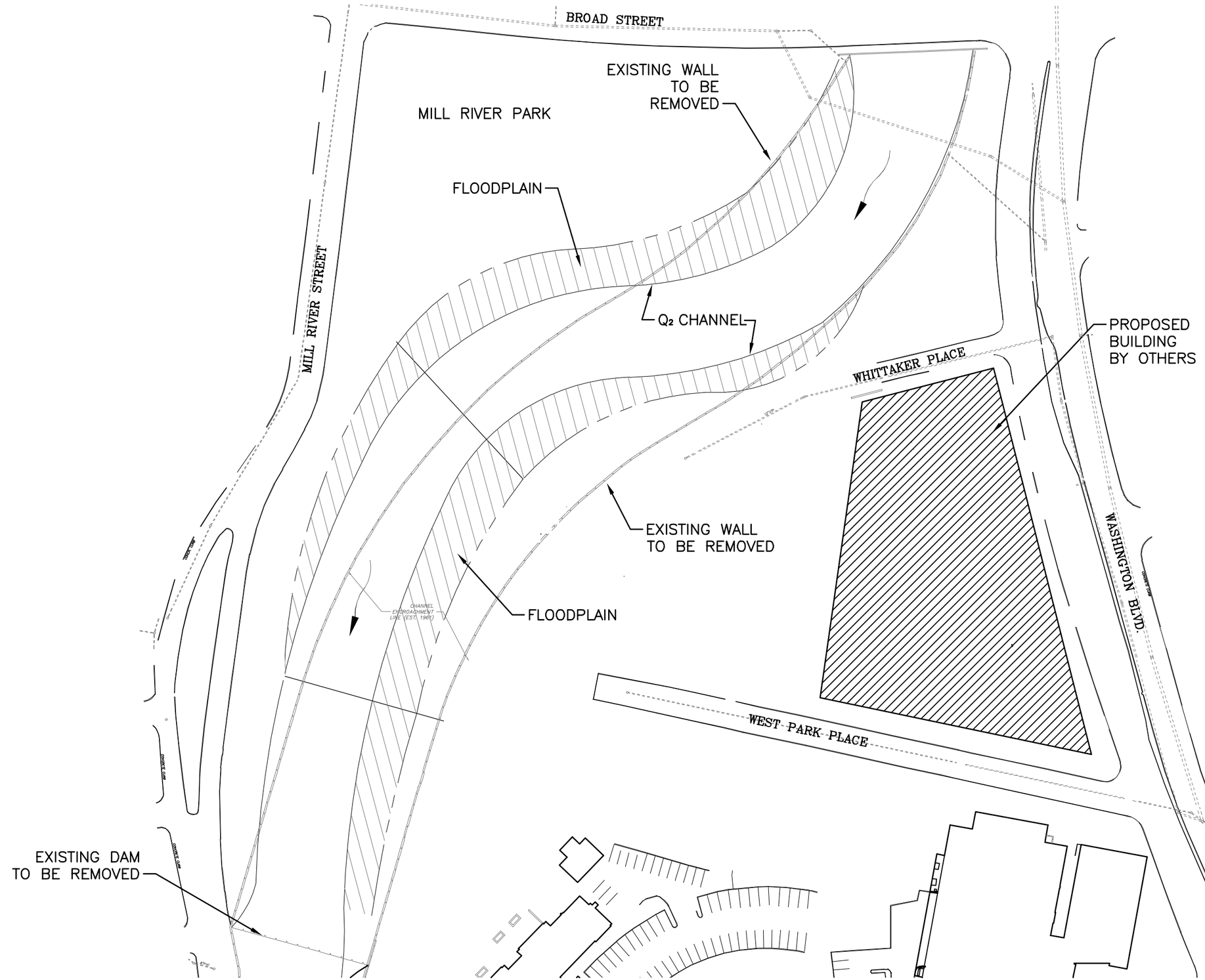
The concrete walls of the Mill Pond would be removed and replaced with gently sloping banks composed of soil stabilized by native vegetation. These vegetated banks would act as a riparian buffer providing shade to the river. A natural floodplain would be restored to provide flood storage for large discharge events without increasing established FEMA flood elevations.

The volume of sediments transported downstream to the estuary and the Federal channel post dam removal is not expected to be significant, especially considering the size of the receiving basin when compared to the size of the current impoundment. Also, the impoundment is presently aggraded with sediments and it is likely that its current trapping capabilities are greatly reduced. Therefore, post dam removal sediment delivery

to the estuary and the Federal channel downstream may not be significantly greater than under the existing regime.

Dam removal would reduce the river's elevation in this reach and require bank regrading and stabilization to create a floodplain that integrates with existing park elevations. Creating a floodplain and terraces may require removing some vegetation. Passage of anadromous and freshwater fish species would be restored to the Mill River, and connections between the river and Long Island Sound would be re-established. Little maintenance would be required to sustain stream channel integrity and water quality. Trails and/or boardwalks would accommodate recreational access to the river. The arrangement of channel form, native plants, boulders, water conditions, and healthy fish and wildlife populations would create an appealing and appropriate functional greenspace in downtown Stamford.

In addition to restoration measures along the river corridor, a trail system would be constructed to replace existing trails and sidewalks displaced by the restoration measures, and to connect the greenway and parks along the river corridor. Interpretive displays could also be added at the restoration sites to improve public understanding of the restoration efforts.



NORTH

GRAPHIC SCALE
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SCALE IN FEET

PROPOSED RIVER RESTORATION
MILL RIVER PARK
STAMFORD, CONNECTICUT

Prepared by:
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Prepared for:
US Army Corp of
Engineers
New England District

US Army Corps of Engineers

Figure 9. Alternative 2 Concept - Dam Removal and River Channel Restoration

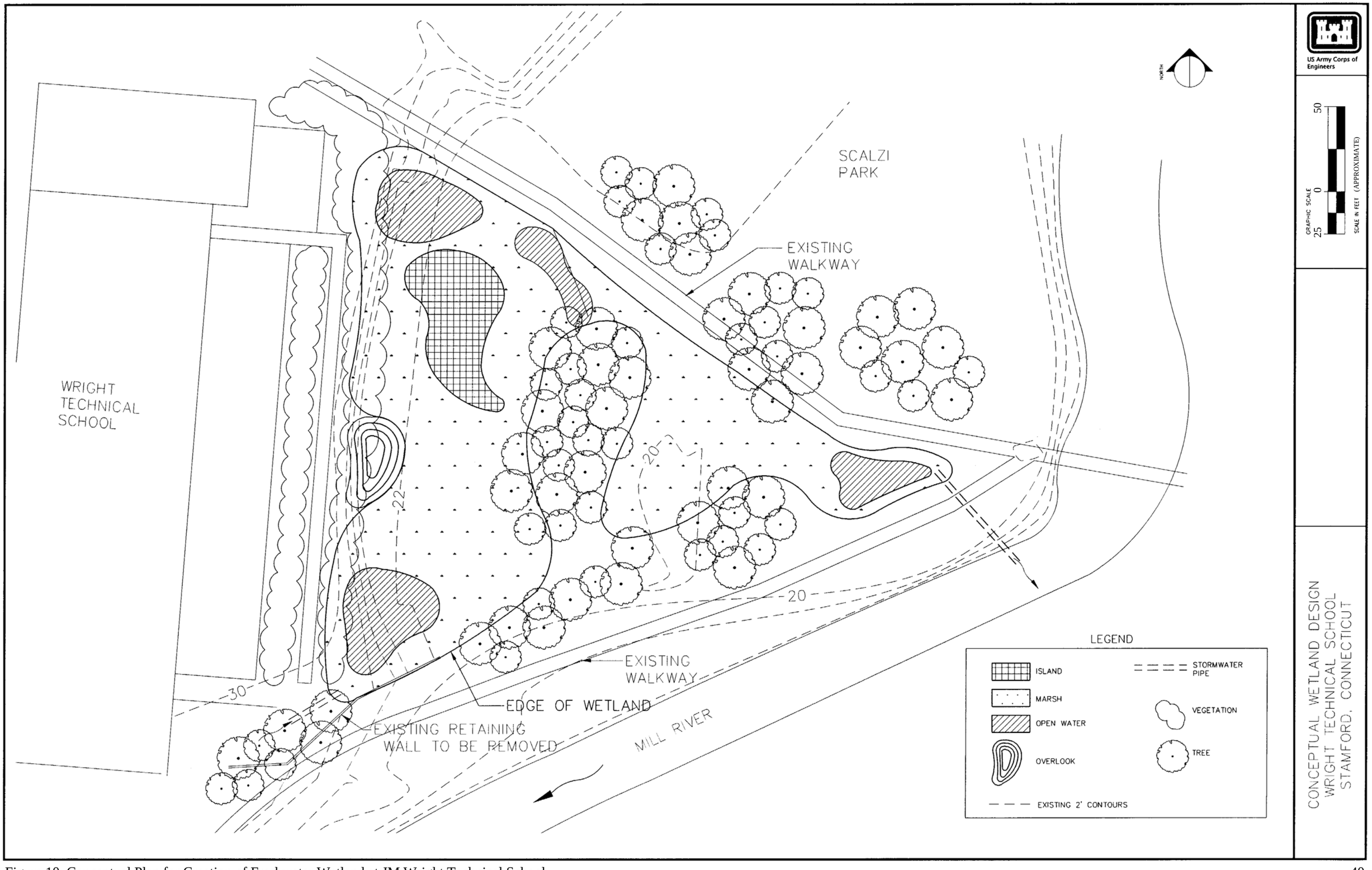

Figure 10. Conceptual Plan for Creation of Freshwater Wetland at JM Wright Technical School

4.3.3 Alternative 3: Dam Removal and Creation of Step Pools

Alternative 3 combines the following measures:

- Removal of the Main Street Dam and concrete retaining walls and creation of a series of stepped pools through a quarter-mile reach of Mill River (See Figure 11), and restoration of 4 acres of riparian habitat
- Additional riparian habitat restoration along the river, totaling 1.53 acres
- Creating a one-acre wetland area adjacent to the river at the J.M. Wright Technical School grounds (See Figure 10)
- Restoration of 0.8 acres of tidal wetlands
- Removal of abandoned concrete blocks and gate structures beneath the Pulaski Street Bridge

Dam removal and sediment removal would occur as described in Alternative 2. However, instead of the riffle-pool system in Alternative 2, a still-water landscape would be maintained in Mill River Park by constructing a series of pools connected by small cascades. Flow control structures would be constructed by using boulders, and would appear to be small natural cascades. The concrete walls around the Mill Pond would be removed and replaced with vegetated banks, functioning in the same manner as described in Alternative 2. On-going dredging and maintenance would be required to manage sedimentation within all six pools. The operation and maintenance costs of the pools would be the responsibility of the city of Stamford and would add costs to the total project cost.

Wetland habitat could be established along the margins of the pools. Passage of fish and other aquatic species would be partially restored in the Mill River, and habitat connectivity would be partially restored between the river and the ocean. Trails and/or boardwalks would accommodate recreational access to the river. The cascades between pools could have restricted passage for some species of fish and other aquatic species.

A cascade pool series was added in this alternative to create still-water pools that retain some of the still-water appearance and function of the existing impoundment behind Main Stream Dam. This cascade pool series would require constant, intensive maintenance. While passage of fish and other aquatic species would be enhanced within the Mill River compared to the no-action alternative, the success rate of passage is reduced when compared to natural stream channel restoration. Furthermore, the landscape and local gradient do not support true step-pool channel morphology. Sedimentation would be expected to occur at an accelerated rate as compared to the current Mill Pond due to the reduced size of the pools. While the uppermost pool would be designed to retain sediment and allow access for sediment removal, continued dredging of all pools would be required to ultimately control sediment buildup.

As in Alternative 2, a trail system would be constructed to replace existing trails and sidewalks displaced by the restoration measures, and to connect the greenway and parks along the river corridor. Interpretive displays could also be added at the restoration sites.

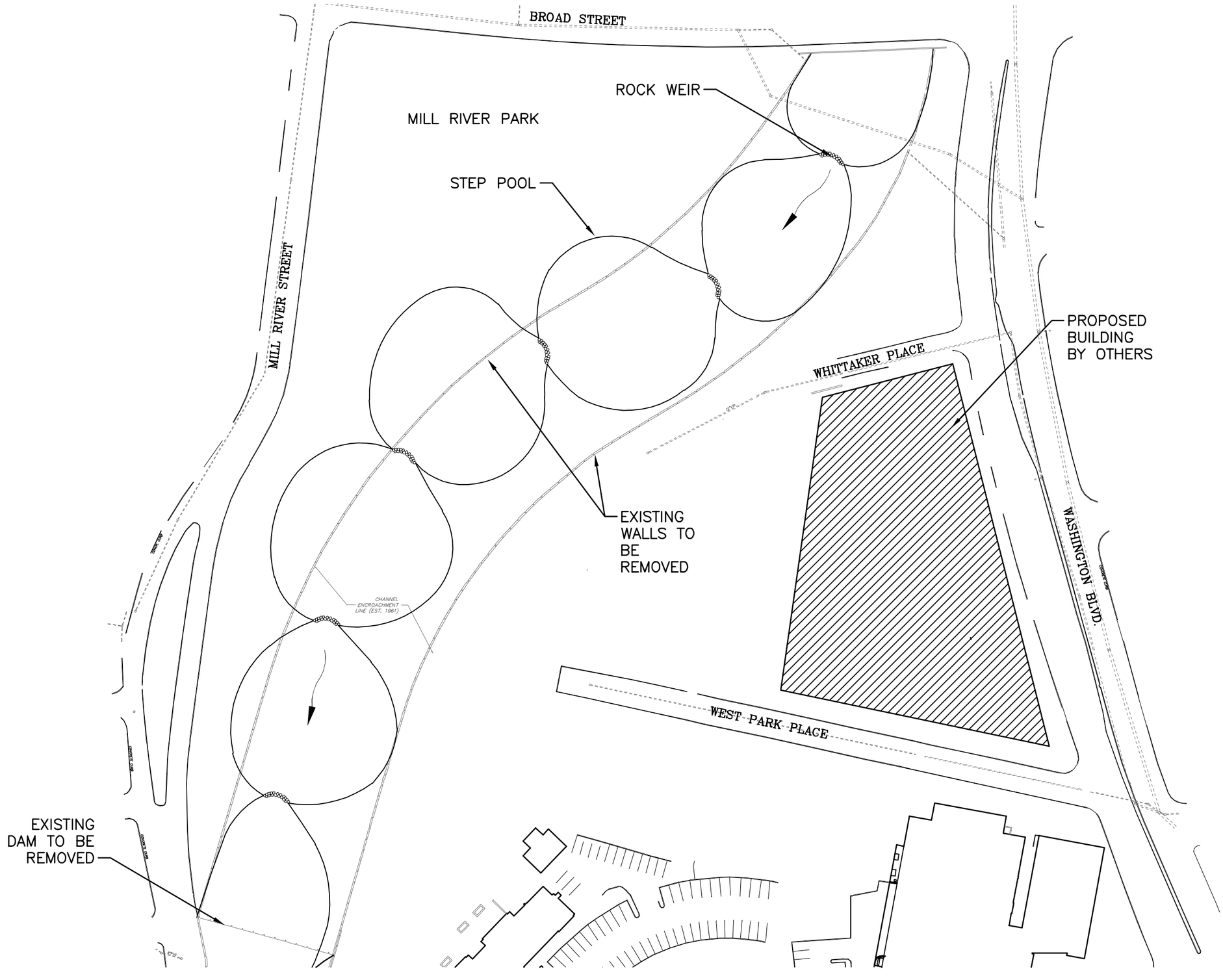

Figure 11. Alternative 3 Concept- Dam Removal and Step Pool Creation

4.3.4 Alternative 4: Partial Removal of Concrete Retaining Walls

Alternative 4 combines the following measures:

- Construction of a fish ladder on the Main Street Dam, while leaving the dam in place, partially removing the concrete retaining walls along the impoundment, and dredging out and widening the impoundment, and restoring 2.9 acres of riparian habitat along the pool (See Figure 12)
- Additional riparian habitat restoration along the river, totaling 1.53 acres
- Creating a one-acre wetland area adjacent to the river at the J.M. Wright Technical School grounds (See Figure 10)
- Restoration of 0.8 acres of tidal wetlands
- Removal of abandoned concrete blocks and gate structures beneath the Pulaski Street Bridge

The Main Street Dam and the Mill Pond would be retained and would be required to be extensively repaired. A fish ladder would be installed on the face of the dam to provide some level of anadromous fish passage. The target species would be river herring. For feasibility level analysis, a small concrete Denil-type fish ladder was chosen and would need to be designed to have a project life of at least 50 years. The specific design of this fish ladder would be provided during the plans and specifications phase of the project. The concrete walls around Mill Pond would be partially removed (approximately 1,000 feet on each side removed; 100 feet remain on each side) and the shoreline of the pond would be reshaped and regraded. Contaminated sediment (approximately 18,600 cy) that has collected behind the dam would be excavated and disposed at a designated site prior to construction. Main Street Dam would be repaired and structurally reinforced. The new shoreline would be regraded to create a floodplain connecting to the park area. The new pond slopes would be stabilized with native upland vegetation to develop a riparian buffer zone around the pond. Existing cherry trees may need to be removed. A fish ladder would be installed at the Main Street Dam to facilitate fish passage. On-going dredging and maintenance would be required to manage sedimentation within the pond. Trails and/or boardwalks would accommodate recreational access to the pond. As in Alternative 2, a trail system would be constructed to replace existing trails and sidewalks displaced by the restoration measures, and to connect the greenway and parks along the river corridor. Interpretive displays could also be added at the restoration sites.

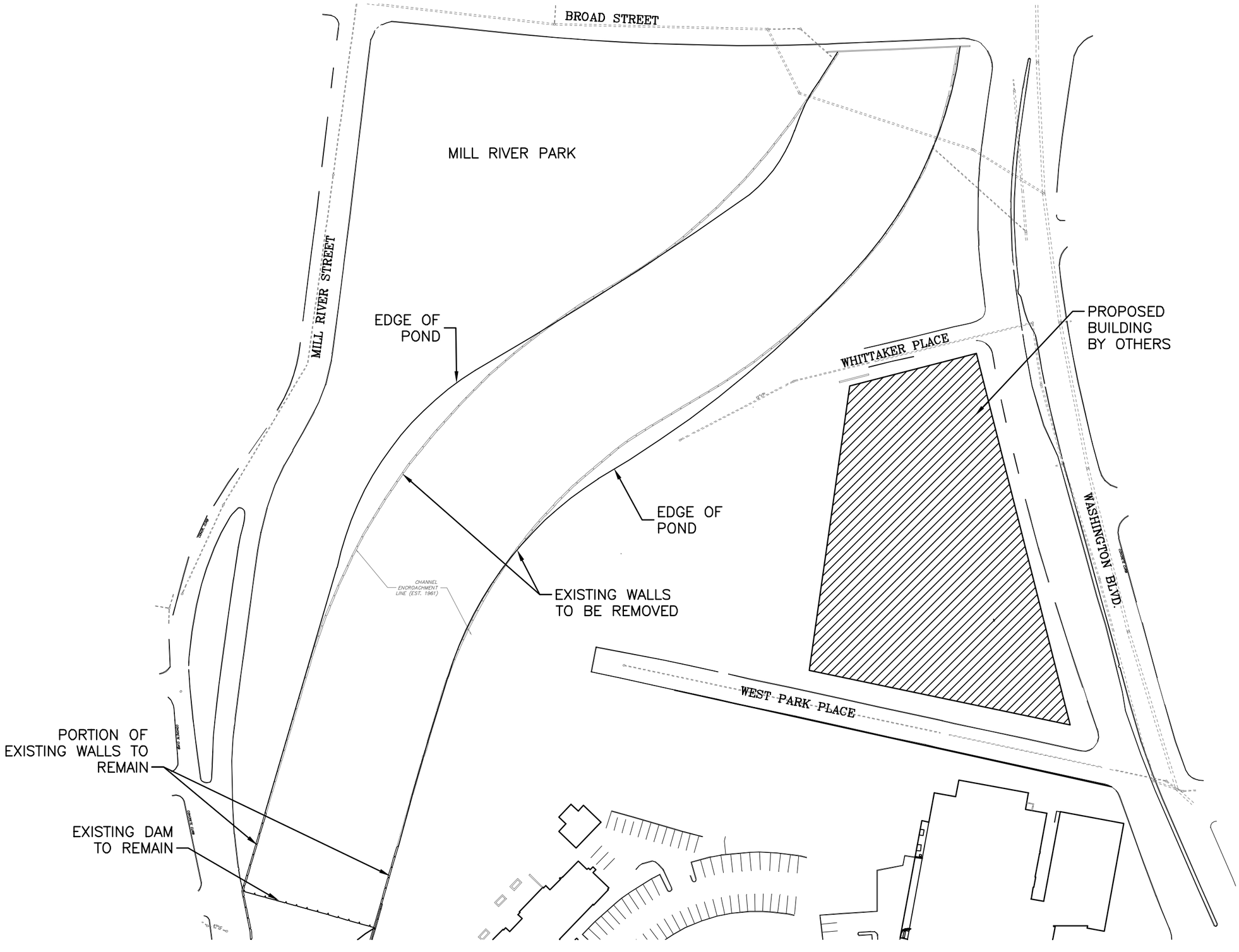

Figure 12. Alternative 4 Concept- Partial Removal of Concrete Retaining Walls

Table 3 outlines the components of each alternative investigated.

Table 3. Components of the Restoration Alternatives.

PROJECT COMPONENTS	NO ACTION	ALT #2	Alt #3	ALT #4
Operate and Maintain Dam	**X**			**X**
Continual Removal of Sediments	**X**		**X**	**X**
Dam Removal		**X**	**X**	
Removal of Existing Sediments	**X**	**X**	**X**	**X**
Restore River Channel		**X**		
Create Step Pools			**X**	
Remove Fish Passage Block in Harbor		**X**	**X**	**X**
Tidal Wetland Restoration		**X**	**X**	**X**
Freshwater Wetland Creation		**X**	**X**	**X**
Riparian Restoration and Exotic Species Removal		**X**	**X**	**X**
Install, Operate and Maintain Fish Ladder				**X**